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Towards a field guide to the trees of the Nee Soon Swamp Forest (VI): *Calophyllum* (Calophyllaceae)

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Abstract. This is the sixth in a series of articles that aim to assist in the identification of the trees of the Nee Soon Swamp Forest, the last remaining substantial tract of freshwater swamp forest in Singapore. This paper provides a key and descriptions, based on characters easily observed in the field and from dried specimens, for the 11 native *Calophyllum* species that are recorded there.

Key words. Calophyllaceae, *Calophyllum*, bintangor, Nee Soon Swamp Forest, trees, field identification

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INTRODUCTION

Calophyllum L. is the largest genus in the family Calophyllaceae with approximately 190 known species (Stevens, 2017). They are mainly medium to large-sized trees or shrubs that can be found in the tropical areas of both the New and Old World. Most species are distributed in the Old World, ranging from eastern Africa to Indo-Malesia and the Pacific, while only approximately 10 species are known in the New World, from Mexico to Central and South America and the Caribbean (Stevens, 1980, 2007). Some species are important sources of timber, food and medicine, thus making them economically valuable (Stevens, 2007; LaFrankie, 2010). Species from this genus can be easily distinguished from those of the other genera in the family based on their characteristic secondary veins that are nearly always parallel, and ovaries with a single basal anatropous ovule.

Calophyllaceae, which was named after the genus, was reinstated and applied to the Clusiaceae subfamily Kielmeyeroideae after the phylogenetic study conducted by Wurdack and Davis (2009) found that Clusiaceae sensu lato was polyphyletic. This has been accepted by the Angiosperm Phylogeny Group III (APG III, 2009) onwards. Morphologically, species from Calophyllaceae can be differentiated from those of Clusiaceae sensu stricto by their stamens which are not fasciculate and anthers that sometimes have big apical glands (LaFrankie, 2010).

For Singapore, Chong et al. (2009) listed a total of 18 native species and varieties of *Calophyllum* and one native species of *Mesua* (*Mesua elegans* (King) Kosterm.) from the family Calophyllaceae. Several species are very common in Singapore's native-dominated secondary forests (Yee et al., 2019). For the Nee Soon Swamp Forest (NSSF), Wong et al. (2013) listed 11 native *Calophyllum* species and varieties, including *Calophyllum wallichianum* Planch. & Tr. var. *wallichianum*, but this name was found to have been misapplied by some authors to the taxon *Calophyllum rufigemmatum* Hend. & Wyatt-Sm. ex P.F.Stevens in Singapore (Seah et al., 2019). *Mesua elegans* does not occur in the NSSF. Wong et al. (2013) did not include *Calophyllum sundaicum* P.F.Stevens even though the type specimen was collected from the locality "Seletar Forest behind Nee Soon Vegetable Garden" (J. Sinclair SFN 39252). We did not record or identify this species during our surveys, but a check on recent collections in the Singapore Botanic Gardens' Herbarium (SING) shows that it persists in the NSSF. Hence, we have included it in this guide.

Here we provide a key and descriptions for the 11 species of *Calophyllum* recorded from the NSSF. Where some characters could not be examined or observed from the specimens collected in the NSSF, i.e., inflorescences, flowers, fruits, seeds and mature tree heights, the description of these features and/or the relevant measurements were referenced from recent revisions and accounts of this genus, namely, Stevens (1980), Whitmore (1989), LaFrankie (2010), Byrne et al. (2018) and Sungkaew et al. (2019). Many collectors and local publications use "NSSF" to refer to the larger area in the northeastern part of Singapore's Central Catchment Nature Reserve (CCNR) that contains the actual freshwater swamp forest but also dry-land forest; where possible we provide our observations on the relative affinity of each species to wet (referring to swampy conditions) or dry (i.e., non-swampy) areas, consistent with and based on the data from the vegetation plots described by Chong et al. (2016).

***CALOPHYLLUM* L.**

(Greek *kalós*, beautiful; *phúllon*, leaf; referring to the attractive leaves)

Usually medium to large-sized evergreen trees, occasionally small trees or shrubs; trunk typically straight, sometimes with buttresses. **Bark** usually smooth with vertical lines of lenticels or distinctive boat- to diamond-shaped fissures especially when young, fissures may become deeper or converge when older, or the bark may appear flaky to scaly; exudates fluid to sticky, clear to white or yellow. **Twigs** more or less flattened to angled, horizontal lines present or absent at the nodes; axillary buds usually inconspicuous and small but can also be notably plump; terminal buds and their associated pair of uppermost axillary buds usually exposed, sometimes with scales, narrow and pointed to plump and conical, often covered with crustaceous to tomentose indumentum (which in some species are whitish in colour when developing), but some are glabrous or have hairs only at the edges of the bud scales, trichomes are usually functional but may also be abortive in some species. **Leaves** simple with opposite and decussate leaf arrangement (true at least for all native *Calophyllum* species in Singapore); exstipulate; coriaceous; blade entire, generally narrower and longer in young plants compared to older ones, blade margin slightly to obviously thickened or not; midrib usually more prominent on lower than upper lamina surface, rounded below in fresh specimens, may appear striate or angled below when dried; secondary veins numerous, parallel, closely or relatively widely and regularly spaced apart, usually perpendicular to or form wide angles with the midrib, often with less prominent latex channels in between; usually petiolate. **Inflorescence** terminal or axillary, branched or unbranched, bearing one to numerous flowers. **Flowers** usually hermaphrodite; tepals 4–many; stamens few to numerous, not obviously fasciculate; filaments free or only slightly connate at base; anthers basifixed, dehiscing lengthwise, sometimes with apical glands; stigma more or less peltate and radiate or irregularly lobed, but could also be slightly expanded and infundibuliform; ovary locules 1; ovules 1, basal, anatropous. **Fruit** drupaceous when mature, with a rather succulent skin and a stone with a single seed inside.

Key references. Stevens (1980: 342–638); Whitmore (1989: 162–196); LaFrankie (2010: 320–325); Byrne et al. (2018: 166–184) and Sungkaew et al. (2019: 432–467).

Notes. *Calophyllum* spp. show variations in the sizes of terminal buds and leaves, as well as the densities of secondary veins and indumentum during and between each stage of development in a single plant (i.e., seedlings, young plants and adult plants), which can make the identification of sterile specimens collected from below the canopy difficult at first. However, after encountering the species in the field, one would be able to recognise their characteristics and differences in time. Users of this field guide are encouraged to consult the key as well as look through the photographs provided to become familiarised with the descriptions of the characters. This field guide tries to present characters most often observed for adult plants or the mature leaves of young plants.

FIELD KEY TO THE *CALOPHYLLUM* SPECIES OF THE NEE SOON SWAMP FOREST

1. Leaf blade below finely to densely hairy to the naked eye or powdery or velvety to the touch 2
– Leaf blade below glabrous or not obviously hairy to the naked eye or to the touch..... 3

2. Leaf blade below powdery hairy, hairs below can be easily rubbed off; leaf apex acute to acuminate; twigs dry whitish to yellowish..... *Calophyllum rubiginosum*
– Leaf blade below velvety hairy, hairs below not easily rubbed off; leaf apex obtuse to short-acuminate; twigs dry blackish..... *Calophyllum dispar* (in part)

3. Midrib below sunken or flattened; terminal buds 1–1.5 mm long, usually non-functional and often caducous ..... *Calophyllum pulcherrimum*
– Midrib below raised; terminal buds usually > 1.5 mm long, functional and more or less persistent..... 4

4. Terminal buds usually enclosed by upright petioles of the uppermost pair of leaves; leaf margin thickened, 0.4–1.2 mm wide..... *Calophyllum teysmannii* var. *teysmannii*
– Terminal buds not enclosed by upright petioles of the uppermost pair of leaves; leaf margin not thickened or only slightly thickened to 0.4 mm wide..... 5

5. Midrib below, terminal buds and twigs often more or less persistently tomentose with rusty-red or greyish brown hairs 6
– Midrib below, terminal buds and twigs glabrous, sub-persistently or sparsely puberulent 8

6. Terminal buds long and broad, 7–30 mm long and 4–6 mm wide ... *Calophyllum lanigerum* var. *austrocoriaceum*
– Terminal buds short and narrow, 2–8 mm long and 1–3 mm wide 7

7. Secondary veins below closely spaced, usually > 10 per 5 mm, two times more closely-spaced above than below

..... *Calophyllum ferrugineum* var. *ferrugineum*

– Secondary veins below widely spaced, usually ≤ 10 per 5 mm, not two times more closely-spaced above than below ..... *Calophyllum dispar* (in part)

8. Terminal buds usually 1–6 mm long 9
– Terminal buds usually > 5 mm and up to 30 mm long 10

9. Petioles usually < 15 mm long; leaf margin noticeably paler than lamina, slightly thickened to 0.4 mm wide; terminal buds 1–4 mm long ..... *Calophyllum tetrapterum* var. *tetrapterum*
– Petioles usually ≥ 18 mm long, leaf margin not paler than lamina, not thickened; terminal buds 3–6 mm long .... *Calophyllum macrocarpum*

10. Mature leaves usually large, 15–34 cm long, 3.2–9.0 cm wide; terminal buds 16–30 mm long, striate .... *Calophyllum wallichianum* var. *incrassatum*
– Mature leaves usually small to medium-sized, 4.3–22.8 cm long, 2.0–5.7 cm wide; terminal buds 5–20 mm long, not striate 11

11. Leaf blade elliptic to oblong, usually small to medium-sized, 4.3–12.5 cm long; leaf apex usually retuse or rounded ..... *Calophyllum sundaicum*
– Leaf blade ovate to sub-elliptic, usually medium to large-sized, 8.1–22.8 cm long; leaf apex usually acute to sub-acute ..... *Calophyllum rufigemmatum*

1. *Calophyllum dispar* P.F.Stevens

(Latin *dispar*, unequal; to emphasize the size difference between the small fruits and medium-sized leaves)

Tree 15–18 m tall; trunk girth to 94 cm, without buttresses. **Bark** yellowish to greyish, smooth or with diamond-shaped fissures; inner bark pinkish to brown; latex yellowish. **Twigs** 1–3.5 mm across, slightly flattened, four-angled with four additional raised lines, drying blackish, sub-persistently brown tomentose/greyish brown puberulent; uppermost pair of axillary buds inconspicuous, rounded, around 1 mm long; terminal buds plump, 3–6 mm long, covered with brown tomentose/sub-appressed hairs. **Leaves** elliptic to ovate, 7.2–18.5 × 1.6–4.8 cm, coriaceous, more or less glabrous on the lamina above, *usually woolly to densely hairy on the lamina below, often with at least a few hairs persistent*; secondary veins conspicuous above and below, raised, *5 to 9 (to 11) veins per 5 mm*; midrib above gradually to rather quickly narrowed, midrib below raised, striate (rarely angled), transiently puberulent to persistently tomentose; apex obtuse to short-acuminate; margin strongly and closely undulate and at most slightly recurved; base cuneate to broadly rounded; petioles 4–10 mm long, broadly and deeply concave above and convex below, transiently to sub-persistently puberulent to tomentose. **Inflorescence** borne from leaf axils along twigs, 7–21 flowers, unbranched (rarely with branches up to 3 mm long with three flowers), lowest internode 2–4 mm long. **Flowers** bisexual; tepals 4. **Fruit** pruinose-brown and strongly wrinkled when dry, spherical to broadly ellipsoid, small, 10 mm or less in diameter, apiculate. — Fig. 1 and Fig. 2.

Singapore localities. NSSF (K. Y. Chong, L. Neo, S. Y. Tan & C. Y. Koh NSSF2-Q213U45; K. Y. Chong, L. Neo, S. Y. Tan, C. Y. Koh, J. W. Loh & R. C. J. Lim NSSF2-Q111T10), Seletar Reservoir (J. Sinclair SFN 39698; P. F. Stevens 716), Mandai Road (M. S. Kiah SFN 37715) and secondary forests elsewhere within the CCNR (e.g., along the Tree Top Walk and forests south of the Upper Peirce Reservoir).

Habitat. In the NSSF, it is found in plots from both wet and dry areas. According to Stevens (1980: 526), this species can be found in swamp forests and on sandy soil and sandstone, 15–1150 m in altitude, outside of Singapore.

Conservation. Nationally Critically Endangered (Tan et al., 2008).

Suggested common name. Small-fruited bintangor.

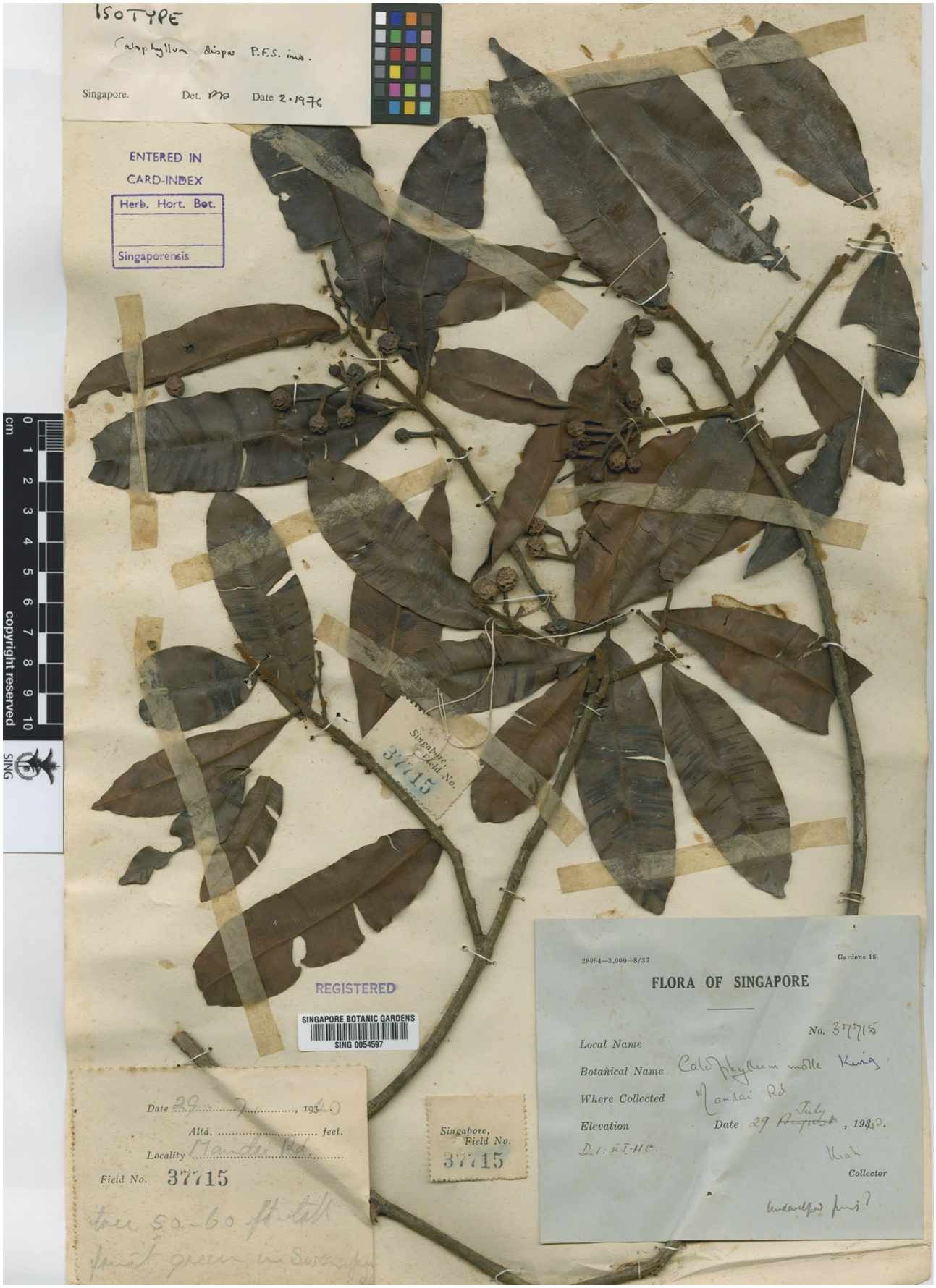

Fig. 1. *Calophyllum dispar*. Herbarium specimen of a fruiting leafy branch, Kiah SFN 37715, Mandai Road, SING barcode number 0054597. Note the size difference between the leaves and fruits.

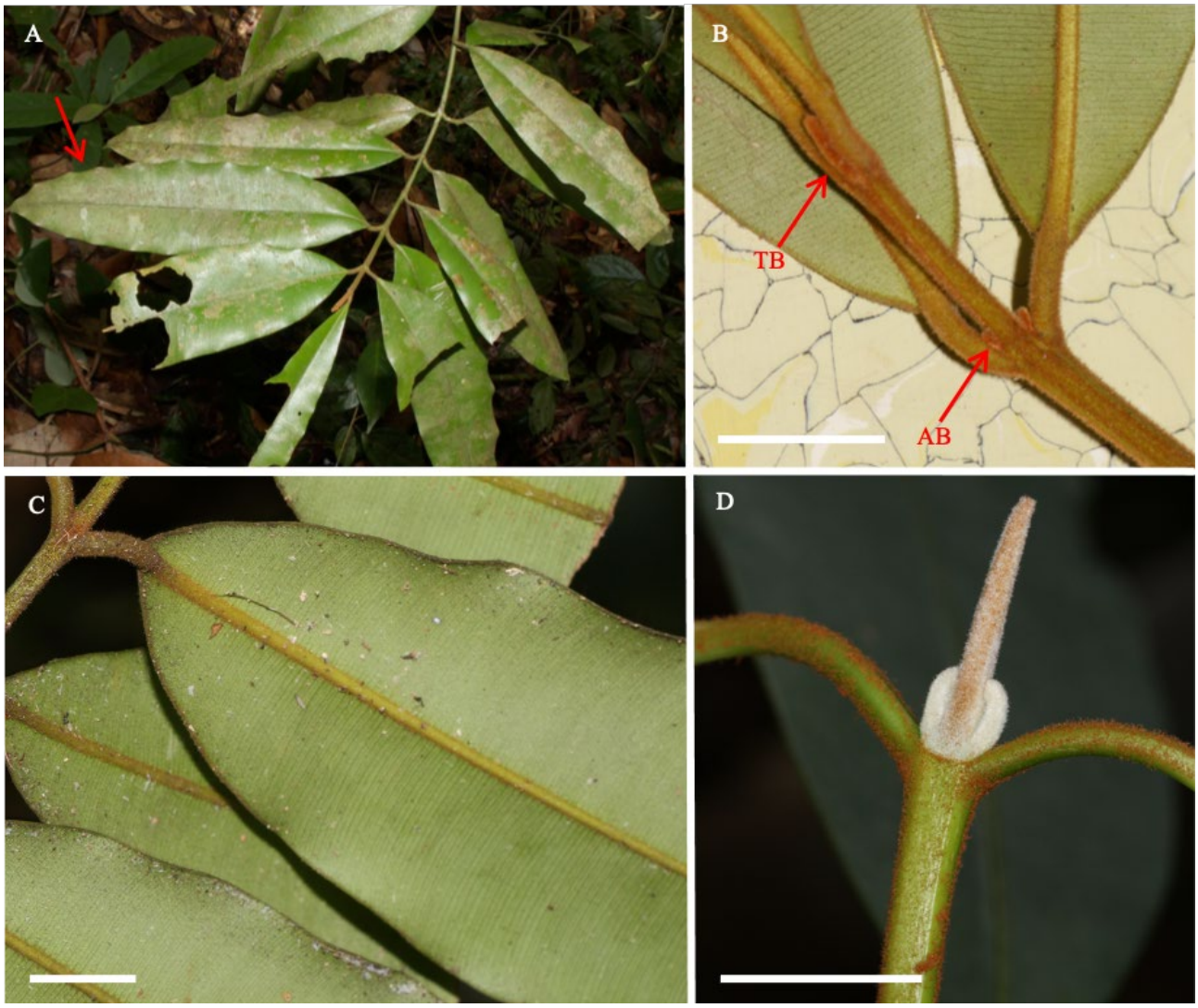

Fig. 2. *Calophyllum dispar*. A, Leaves with strongly undulate margins (red arrow) on a twig; B, Plump terminal bud (TB) and a pair of rounded axillary buds (AB) covered with brown tomentose hairs; C, Undersides of the leaves showing raised midribs and prominent secondary veins that are relatively widely spaced; D, Terminal bud of a young shoot covered in mostly white and some brown puberulent hairs. Scale bars = 1 cm [B, C]; 0.5 cm [D].

Remarks. Some fresh specimens were observed to have terminal buds covered in largely white and some brown puberulent hairs (Fig. 2D). It appears that the terminal buds of young shoots of this species can occasionally be covered in hairs that are white and/or lighter-coloured. A single specimen collected from the NSSF (K. Y. Chong, L. Neo, S. Y. Tan, C. Y. Koh NSSF2-Q4T61) has been determined as *Calophyllum dispar* even though both sides of the lamina and the axillary buds are glabrous. This identification is based on the relatively widely spaced secondary veins below, with approximately 5–6 veins per 5 mm—one of the distinguishing characters of this species.

2. *Calophyllum ferrugineum* Ridl. var. *ferrugineum*

(Latin *ferrugineus*, rusty-red brown; referring to the colour of the hairs)

Tree 7.5–22 m tall; trunk girth to 135 cm, without spurs or buttresses. **Bark** greyish brown, sparsely striate with irregular-shaped markings; inner bark reddish orange; latex clear yellow, sticky. **Twigs** 1–3 mm across, strongly angular, drying brown (pruinose when young), glabrous to more or less persistently tomentose; uppermost pair of axillary buds inconspicuous, rounded, 2–4.4 mm long; terminal buds conical, bluntly pointed, 2–8 mm long, *tomentose to short-tomentose, covered with rusty-red brown hairs*. **Leaves** elliptic to oblong, 5.5–17.9 × 1.6–5.5 cm, coriaceous; more or less glabrous on both surfaces except for midrib above and below; secondary veins above fine and sub-obscure, appearing twice more closely-spaced than below, below more apparent and slightly raised, (10 to) 12 to 19 veins per 5 mm, *midrib above glabrescent, below often more or less persistently tomentose*; apex retuse to obtuse or rounded; margin slightly recurved; base cuneate to attenuate; petioles 3–16(–25) mm long, broadly and shallowly concave above, convex below, glabrous or occasionally tomentose below. **Inflorescence** borne from leaf axils, 3–13 flowers, not flabellate or branched,

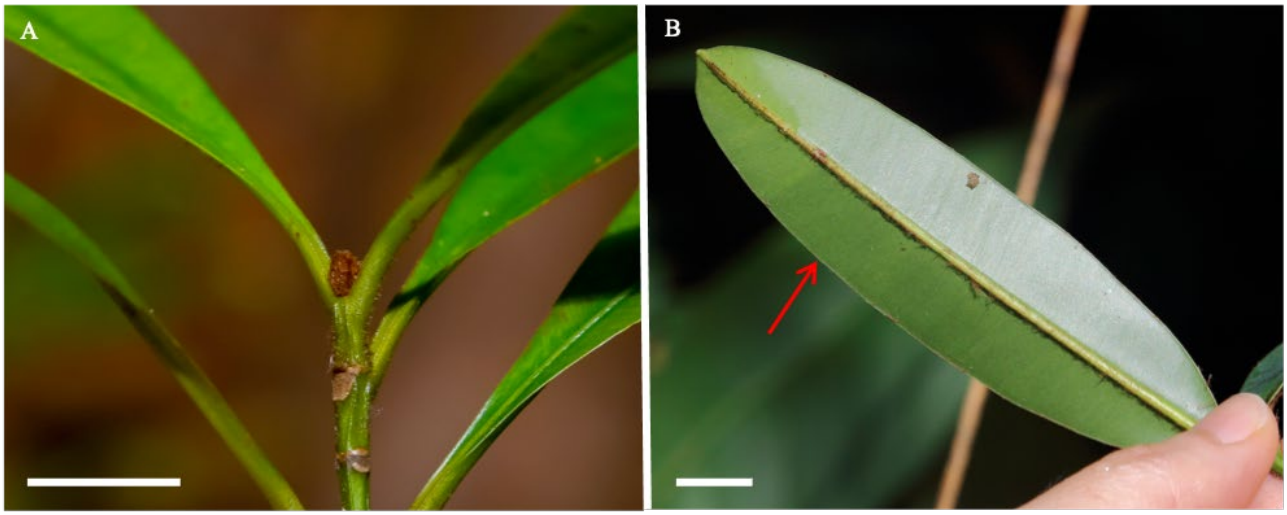

Fig. 3. *Calophyllum ferrugineum* var. *ferrugineum*. A, Blunt terminal bud of a young specimen covered with rusty-red brown hairs, twig strongly angular; B, Midrib below more or less persistently tomentose and leaf blade slightly recurved at margin (red arrow). Scale bars = 2 cm [A, B].

Fig. 4. *Calophyllum ferrugineum* var. *ferrugineum*. Terminal bud of a young shoot covered in mostly white and some rusty-brown tomentose hairs.

lowest internode tomentose, (2–)10–50 mm long. **Flowers** bisexual; tepals 4(–8). **Fruit** long-ellipsoid, pointed at apex, 16–26 × 12–16 mm. — Fig. 3. and Fig. 4.

Singapore localities. NSSF (K. Y. Chong, L. Neo, S. Y. Tan & C. Y. Koh NSSF2-Q404aT49), Bukit Timah Nature Reserve, Singapore Botanic Gardens Upper Seletar Reservoir (A. T. Gwee, P. T. Chew, H. K. Lua & D. Liew et al. SING 2008-122; A.T. Gwee SING 2010-613) and secondary forests elsewhere within the CCNR (e.g., forests surrounding the MacRitchie and Upper Peirce reservoirs).

Habitat. In the NSSF, it is found in both dry and wet plots. Outside of the NSSF in Singapore, this species can also be commonly encountered in other dry-land secondary forests. According to Stevens (1980: 459), this taxon can be found in lowland mixed dipterocarp forest or hills, at altitudes up to 425 m, outside of Singapore. It is also sometimes found in seasonally flooded forests in Johor.

Conservation. Not Threatened (Chong et al., 2009).

Suggested common name. Ferruginous bintangor.

Remarks. Some fresh specimens were observed to have terminal buds covered in mostly white and some rusty brown tomentose hairs (Fig. 4). As the terminal buds of other shoots on the same specimens are covered in rusty-red brown hairs, a character typical of this species, and the leaf venation also match that of the species, the specimens were determined as *Calophyllum ferrugineum* var. *ferrugineum*. It appears that the terminal buds of this species are occasionally covered in white and/or lighter-coloured hairs when the shoots are young.

3. *Calophyllum lanigerum* Miq. var. *austrocoriaceum* (T.C.Whitmore) P.F.Stevens

(Latin *laniger*, wool-bearing; referring to the texture of the hairs;
Latin *australis*, southern; *coriaceus,* leathery; referring to the hypothesised relationship to the species *Calophyllum coriaceum*)

Tree (2.1–)4.5–21 m tall; trunk girth to 150 cm, usually without buttresses. **Bark** yellowish to greyish, with vertical rows of lenticels or boat-shaped fissures; inner bark pale pink to deep red; latex clear yellow, sticky. **Twigs** 2.5–6 mm across, strongly flattened, rounded to strongly four-angled, drying dark brown to black, *persistently tomentose*; uppermost pair of axillary buds rounded, 1–5 mm long; terminal buds plump, 7–30 mm long, covered with brown tomentose or greyish brown sub-tomentose hairs. **Leaves** narrowly ovate to oblong, 5.5–26.3 × 2.1–7.7 cm, coriaceous; secondary veins sub-obscure to conspicuous above and below, (5 to) 7 to 15 veins per 5 mm; midrib raised, sub-persistently tomentose above and below, rounded to striate below; apex rounded to retuse or sub-acute; margin not undulate to distinctly so and flat to slightly recurved; base rounded to cuneate or acute; petioles 11–33 mm long, broadly and shallowly (rarely narrowly) concave above, convex and persistently tomentose below. **Inflorescence** borne from leaf axils, 7–21 flowers, unbranched, lowest internode 4–20 mm long. **Flowers** bisexual; tepals 8 (rarely 6). **Fruit** spherical to ellipsoid or obovoid, usually apiculate, sharply, closely and shallowly wrinkled when dry, (18–)22–29 × (17–)20–24 mm. — Fig. 5 and Fig. 6.

Singapore localities. NSSF (J. F. Maxwell 82-54), MacRitchie Reservoir (C. K. Yeo SING 2012-182; W. F. Ang SING 2012-270; Mhd Shah & A.R. Mhd Ali MS 3936), Kallang Reservoir (K. Sidek SK 609), Singapore Botanic Gardens and secondary forests elsewhere within the CCNR (e.g., along the Tree Top Walk and forests south of the Upper Peirce Reservoir).

Habitat. This species was not recorded during plot surveys in the NSSF. It can be encountered in other dry-land secondary forests in Singapore. According to Stevens (1980: 359), this taxon has been found to grow in a variety of habitats—peat swamp forests at lower elevations, heath forests, sandy soil areas near sea and mixed dipterocarp lowland rainforest, up to 950 m in altitude.

Conservation. Nationally Endangered (Tan et al., 2008).

Suggested common name. Southern woolly bintangor.

Remarks. Some fresh specimens were observed to have terminal buds covered in mostly white and some rusty brown tomentose hairs (Fig. 5C). It appears that terminal buds of this species can occasionally be white and/or lighter-coloured when the shoots are young.

4. *Calophyllum macrocarpum* Hooker.f.

(Greek *macro*, large; *carpa*, fruit; referring to the large fruits)

Tree 8–45 (–?60) m tall; trunk girth to 242 cm, usually without buttresses but small buttresses may be present. **Bark** yellowish brown initially, and dark brown to blackish subsequently with deep and coarse boat-shaped fissures, scaling on ridges, inner bark red; latex orange, clear (becoming cloudy), or rarely pinkish. **Twigs** 2–3.5 mm across, slightly flattened, sharply four-angled, drying brown to blackish, covered with transient, sparse brown hairs; uppermost pair of axillary buds inconspicuous, rounded, up to 3 mm long; terminal buds plump, 3–6 mm long, covered with short tomentose hairs. **Leaves** oblong to elliptic, rarely ovate to obovate, 9.0–24.9 × 3.1–6.5 cm, coriaceous; secondary veins obvious, raised above and below, (4 or) 5 to 10 (to 13) veins per 5 mm; midrib above raised or not (surrounding lamina raised), below raised, rounded to striate, sparsely tomentose or glabrous; *apex bluntly and shortly acuminate*, rarely acute; margin slightly recurved or otherwise, barely undulate; base cuneate; petioles 18–31 mm long, flat to shallowly concave above, convex below, glabrous, drying brown to black. **Inflorescence** borne from leaf axils, typically 7–15 flowers, unbranched or occasionally with three-flower branches up to 5 mm long, lowest internode 2–12 mm long. **Flowers** bisexual, tepals 8 (rarely 10).

Fig. 5. *Calophyllum lanigerum* var. *austrocoriaceum*. A, Plump terminal bud covered with brown tomentose hairs; B, Leafy twigs growing in the canopy; C, Terminal bud of a young shoot covered in mostly white hairs, D, Lower surface of the lamina showing tomentose midrib, relatively widely spaced secondary veins and slightly recurved leaf margin (red arrow). Scale bars = 1 cm [A, C, D].

Fruit ellipsoid, apex acute, coarsely wrinkled, irregularly and finely longitudinally striate when dry, 80–127 × 45–60 mm. — Fig. 7 and Fig. 8.

Singapore localities. NSSF (recorded in the plots but not vouchered) and Bukit Timah Nature Reserve (M. S. Khoo & N.H. Nik Faizu KMS 31; M. S. Khoo KMS 81; E. Tang & K. Sidek 1014). No specimens from the NSSF were catalogued in the SING at the time of writing.

Habitat. *Calophyllum macrocarpum* is uncommon in the NSSF, where it has only been recorded in wet plots. According to Stevens (1980: 456), the species can be found growing by streams in mixed dipterocarp forest. It also grows in lowland forest on acidic and sandy soil, as well as forests that occasionally get flooded, up to an altitude of 792 m.

Conservation. Nationally Critically Endangered (Tan et al., 2008).

Suggested common name. Large-fruited bintangor.

Fig. 6. *Calophyllum lanigerum* var. *austrocoriaceum*. Herbarium specimen of a flowering leafy branch, W. F. Ang SING 2012-270, MacRitchie Reservoir, SING barcode number 0176994.

Fig. 7. *Calophyllum macrocarpum*. Herbarium specimen showing the leaves and large fruits, M. S. Khoo, KMS 81, Bukit Timah Nature Reserve, SING barcode number 0123554.

Fig. 8. *Calophyllum macrocarpum*. Herbarium specimen of a young leafy twig, M. S. Khoo & N. H. Nik Faizu, KMS 31, Bukit Timah Nature Reserve, SING barcode number 0123555. Note the oblong leaf blades and shortly acuminate leaf apices.

5. *Calophyllum pulcherrimum* Wall. ex Choisy
(Latin *pulcherrimum*, most beautiful; probably referring to the attractive many-flowered inflorescences)

Tree 10–23(–30) m tall; trunk girth to 125 cm, rarely with buttresses to 1-m tall. **Bark** yellowish-brown, often mottled with vertical lines of lenticels or boat-shaped fissures, or cracked; inner bark pinkish to mid-red; latex clear yellow, sticky. **Twigs** 0.5–2 mm across, strongly angular, drying brown to dark brown, glabrous; uppermost axillary buds inconspicuous, rounded, up to 1 mm long; *terminal buds often non-functional*, narrowly conical, abruptly pointed, 1–1.5 mm long, glabrous or covered with yellowish to light brown fine hairs. **Leaves** elliptic to sub-oblong (rarely obovate), 3.3–9.8 × 1.0–3.5 cm, coriaceous; secondary veins sub-obscure to apparent above and below, slightly raised, 7 to 13 (to 17) veins per 5 mm; *midrib raised above, flat to sunken below*; apex bluntly acuminate (rarely acute to sub-rounded); margin not recurved; base acute to attenuate; petioles 2–10 mm long, deeply concave above, convex below, glabrous. **Inflorescence** borne from leaf axils along twigs, 7–17 flowers, unbranched, lowest internode < 2.5 mm long. **Flowers** bisexual, tepals 4 (rarely 8). **Fruit** ovoid to spherical, ovoid, apex sharply pointed, outer surface smooth when young, apiculate or otherwise when older, strongly wrinkled when dry, 15–17 × 12–18 mm. — Fig. 9.

Singapore localities. NSSF (K. Y. Chong, L. Neo, S. Y. Tan & C. Y. Koh NSSF2-Q301U53), Bukit Mandai (H. N. Ridley 8942), Bukit Timah Nature Reserve, Chan Chu Kang (H. N. Ridley s.n. SING barcode number 0207010), Changi, MacRitchie Reservoir, Mandai Forest (H. K. Lua & I. Hassan SING 2011-037), Seletar Reservoir, Pulau Tekong, Pulau Ubin, Tanjong Gul (J. Sinclair 10762), Woodlands/Kranji (H. N. Ridley 260) and secondary forests elsewhere within the CCNR (e.g., forests surrounding the Upper Peirce Reservoir), Western Catchment and Sentosa Island.

Habitat. *Calophyllum pulcherrimum* can be commonly found in the NSSF and has been recorded in both wet and dry plots. Outside of the NSSF in Singapore, this species can also be frequently encountered in more mature dry-land secondary forests as well as other forest fragments that have experienced minimal disturbances from past cultivation practices. Outside Singapore, it can also be found in mixed dipterocarp forest up to 300–500 m in altitude and on sandy soil, beaches, dry-land with scrubby patches and swamp forests (Stevens, 1980: 339).

Conservation. Not Threatened (Chong et al., 2009).

Suggested common name. Small-leaved bintangor.

6. *Calophyllum rubiginosum* M.R.Henderson & Wyatt-Smith
(Latin *rubiginosus*, rusty-red; referring to the conspicuous and persistent rust-coloured hairs)

Tree 7.5–39 m tall; trunk girth to 242 cm, without buttresses but has small spurs. **Bark** brownish initially, yellowish to greyish subsequently, with shallow/fine and long fissures, or wrinkled with small cracks, flaking or scaling; inner bark red; latex white, sticky or otherwise. **Twigs** 1.5–3 mm across, flattened, strongly two- or four-angled, *drying whitish to yellowish*, brown-tomentose, rarely puberulent; uppermost axillary buds pointed, 1–4 mm long; terminal buds plump, 5–15 mm long, covered with brown, short tomentose to puberulent hairs. **Leaves** elliptic to sub-oblong or ovate, 6.6–22.0 × 2.4–8.2 cm, coriaceous, glabrous above, *finely powdery hairy below, hairs below can be easily rubbed off*; secondary veins faint above and below, obscured below by fine hairs, raised or depressed, 8 to 14 veins per 5 mm; midrib sharply raised above, strongly raised and striate below; apex acute to acuminate; margin deeply and distantly undulate, slightly recurved; base acute to sub-decurrent, rarely rounded; petioles 6–22 mm long, narrowly to broadly concave above, convex and short-tomentose below. **Inflorescence** typically terminal, sometimes from adjacent leaf axils, 7–15 flowers, unbranched, often flabellate, rarely solitary terminal flower, lowest internode 5–17 mm long. **Flowers** bisexual, tepals (4 or) 8. **Fruit** ovoid to ellipsoid, apex acute, brown, deeply and distinctly wrinkled when dry, 20–22 × 14–18 mm. — Fig. 10 and Fig. 11.

Singapore localities. NSSF (K. Y. Chong, L. Neo, S. Y. Tan & C. Y. Koh NSSF2-Q307U35 & NSSF2- Q320aU75), Upper Seletar Reservoir (A. T. Gwee, P.T. Chew, H. K. Lua & D. Liew et al. SING 2008-118), MacRitchie Reservoir (A. T. Gwee SING 2009-731; J. Sinclair SFN 39634), Bukit Timah Nature Reserve and secondary forests elsewhere within the CCNR (e.g., the Mandai forests and forests surrounding the Upper Peirce Reservoir).

Habitat. In the NSSF, it was found predominantly in dry plots although it also occurred in wet plots. Outside of the NSSF in Singapore, this species has been recorded in relatively mature dry-land secondary forests. According to Stevens (1980: 640), the species can also be found outside of Singapore in lowland forests, 30–500 m in altitude.

Conservation. Nationally Endangered (Tan et al., 2008).

Suggested common name. Rusty-haired bintangor.

Fig. 9. *Calophyllum pulcherrimum*. A, Yellowish-brown bark mottled with vertical lines of lenticels; B, Pinkish inner bark; C, Narrowly conical terminal bud (TB) (usually non-persistent) and raised midrib above (MR); D, Depressed/sunken midrib below. Scale bars = 1 cm [B]; 2 cm [C, D].

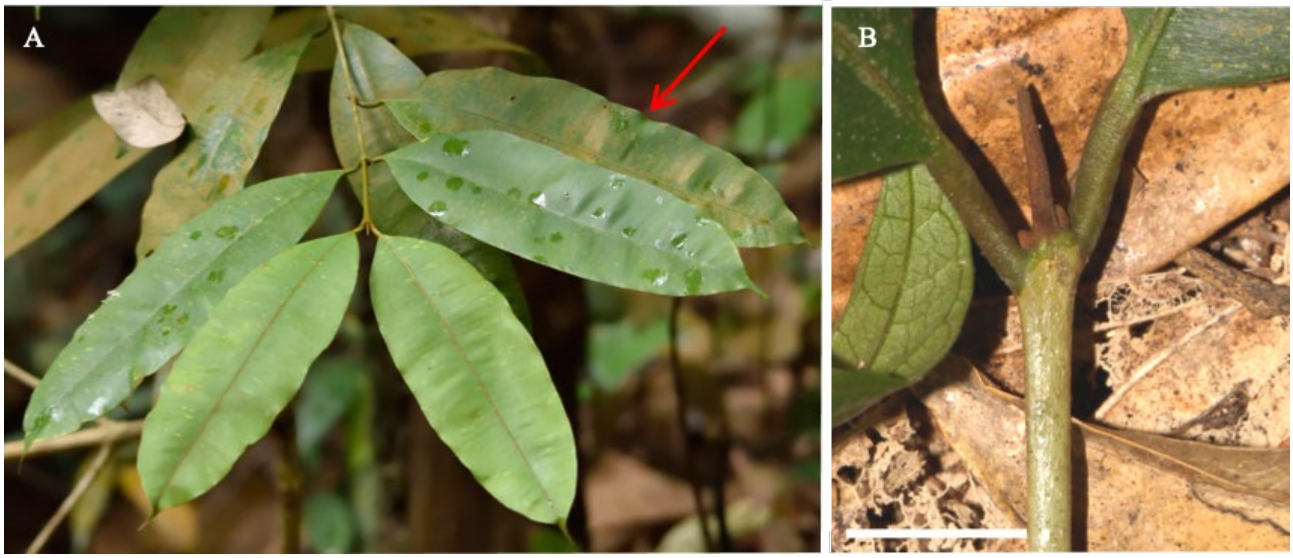

Fig. 10. *Calophyllum rubiginosum*. A, Leafy twig showing sub-oblong leaf blades, undulate leaf margins (red arrow) and acuminate leaf apices; B, Pointed and slightly stout terminal bud covered with brown hairs and whitish twig. Scale bar = 1 cm [B].

Fig. 11. *Calophyllum rubiginosum*. Leaf lower surface showing fine rust-coloured hairs along the midrib. Scale bar = 2 cm.

7. *Calophyllum rufigemmatum* Henderson & Wyatt-Smith ex P.F.Stevens
(Latin *rufus*, reddish; *gemma*, bud; referring to the reddish-brown buds)

Tree 20–48 m tall; trunk girth to 754 cm, usually without spurs or buttresses. **Bark** grey to brown, deeply fissured; inner bark pink to red or brown; latex clear, yellow, sticky. **Twigs** 1.5–4 mm across, flattened, weakly four-angled, often with inconspicuous transverse raised lines at nodes, drying blackish, sub-persistently rufous-puberulent to short-tomentose; uppermost axillary buds pointed, 1–4 mm long; terminal buds narrowly conical to plump, (2.5–)4.0–20.0 mm long, *covered with rufous-puberulent to tomentose hairs*. **Leaves** ovate to sub-elliptic (leaves of young plants sometimes narrowly elliptic), (6.7–)8.1–22.8(–32.5) × 2.2–5.7(–7.5) cm, coriaceous; secondary veins sub-obscure, rarely sub-apparent above and below, raised, (11 to) 13 to 18 veins per 5 mm; midrib slightly raised above or otherwise (surrounding lamina obscurely raised), raised and striate below, sub-persistently puberulent to short-tomentose on both surfaces; apex acute to sub-acute; margin fairly distantly undulate, not recurved to slightly recurved; base acute or cuneate to broadly rounded and often slightly asymmetrical; petioles slender, 6–30 mm long, concave above, convex below, sub-persistently tomentose, drying black. **Inflorescence** borne from foliate axils, 5–7 flowers, unbranched, short and congested, lowest internode 1–5 mm long. **Flowers** bisexual, tepals 4(–8). **Fruit** spherical to sub-obovoid, apex rounded, brown to greyish brown with broad, longitudinal ridges/fine wrinkles when dry, (26–)30–44 × 24–32 mm. — Fig. 12.

Singapore localities. NSSF (A. Samsuri, S. K. Ganesan, S. Lee, P. Leong & A. T. Gwee NES 224), Mandai Forest (J. Sinclair SFN 39605; A. T. Gwee et al. SING 2009-23a) and Bukit Timah Nature Reserve.

Habitat. In the NSSF, it was found in both wet and dry plots. According to Stevens (1980: 355), it can be found in mixed dipterocarp forest, on ridges, slopes and/or other well-drained areas, 5–305 m in altitude.

Conservation. Nationally Endangered (Tan et al., 2008).

Suggested common name. Red-budded bintangor.

Remarks. Specimens that were examined have a variety of leaf shapes, from ovate to narrowly elliptic.

Fig. 12. *Calophyllum rufigemmatum*. A, Young sapling; B, Brownish grey bark and reddish inner bark; C, Narrowly conical terminal bud covered with rufous hairs and weakly four-angled twig (red arrow); D, Ovate leaf blade. Scale bars = 2 cm [B, C].

8. *Calophyllum sundaicum* P.F.Stevens
(of Sundaland; referring to the areas of the species distribution)

Tree 22–28 m tall; trunk girth to 204 cm, usually without buttresses. **Bark** brown to yellowish, with lenticels or shallow and closely-spaced fissures; inner bark pale to dark red; latex yellow, clear, very sticky. **Twigs** 2–4 mm across, four-angled, drying dark brown to blackish, brown puberulent when young; uppermost pair of axillary buds sub-rounded, 1.5–5 mm long; terminal buds plump, 5–13 mm long, covered with brown to greyish puberulent to sub-tomentose hairs. **Leaves** elliptic to oblong, 4.3–12.5 × 2.0–5.7 cm, coriaceous; secondary veins sub-obscure above and below, *11 to 18 veins per 5 mm*; midrib above usually narrowing near base, raised below, puberulent above and below, striate to sub-angled (edges depressed) below; *apex retuse (rounded to sub-acute)*; margin not undulate to slightly so and recurved; base cuneate to rounded; petioles 7–23 mm long, concave to V-shaped above, convex below, puberulent when young. **Inflorescence** borne from leaf axils, 7–11 flowers, unbranched, lowest internode (1.5–)4–18 mm long. **Flowers** bisexual; tepals 4. **Fruit** ellipsoid, rounded at apex, brown, pruinose, wrinkled when dry, 15–21 × 10–14 mm. — Fig. 13, Fig. 14, and Fig. 15.

Singapore localities. NSSF (H.K. Lua & J. M. Heng SING 2018-699), Upper Peirce Reservoir (E. Tang & K. Sidek 57), Mandai Road (J. Wyatt-Smith 40268), Bukit Kallang (Mhd Shah & A.R. Mhd. Ali MS 4219), Seletar Forest behind Nee Soon Vegetable Garden (J. Sinclair SFN 39252) and Jurong (E. J. H. Corner SFN 26047).

Habitat. This species is not frequently encountered in the NSSF and was not recorded during plot surveys. According to Stevens (1980: 469), this taxon is common in peat swamp forests, up to 40 m in altitude.

Conservation. Nationally Critically Endangered (Tan et al., 2008).

Suggested common name. Sunda bintangor.

Fig. 13. *Calophyllum sundaicum*. Herbarium specimen of a young leafy twig and four individual leaves, H. K. Lua & J. M. Heng, SING 2018-699, Mandai Track 7, Nee Soon Swamp Forest, SING barcode number 0273958.

Fig. 14. *Calophyllum sundaicum*. Herbarium specimen of a leafy twig, Mhd Nur, SING barcode number 0017924. Note the retuse apices in most leaves and rounded to sub-acute apices in the others.

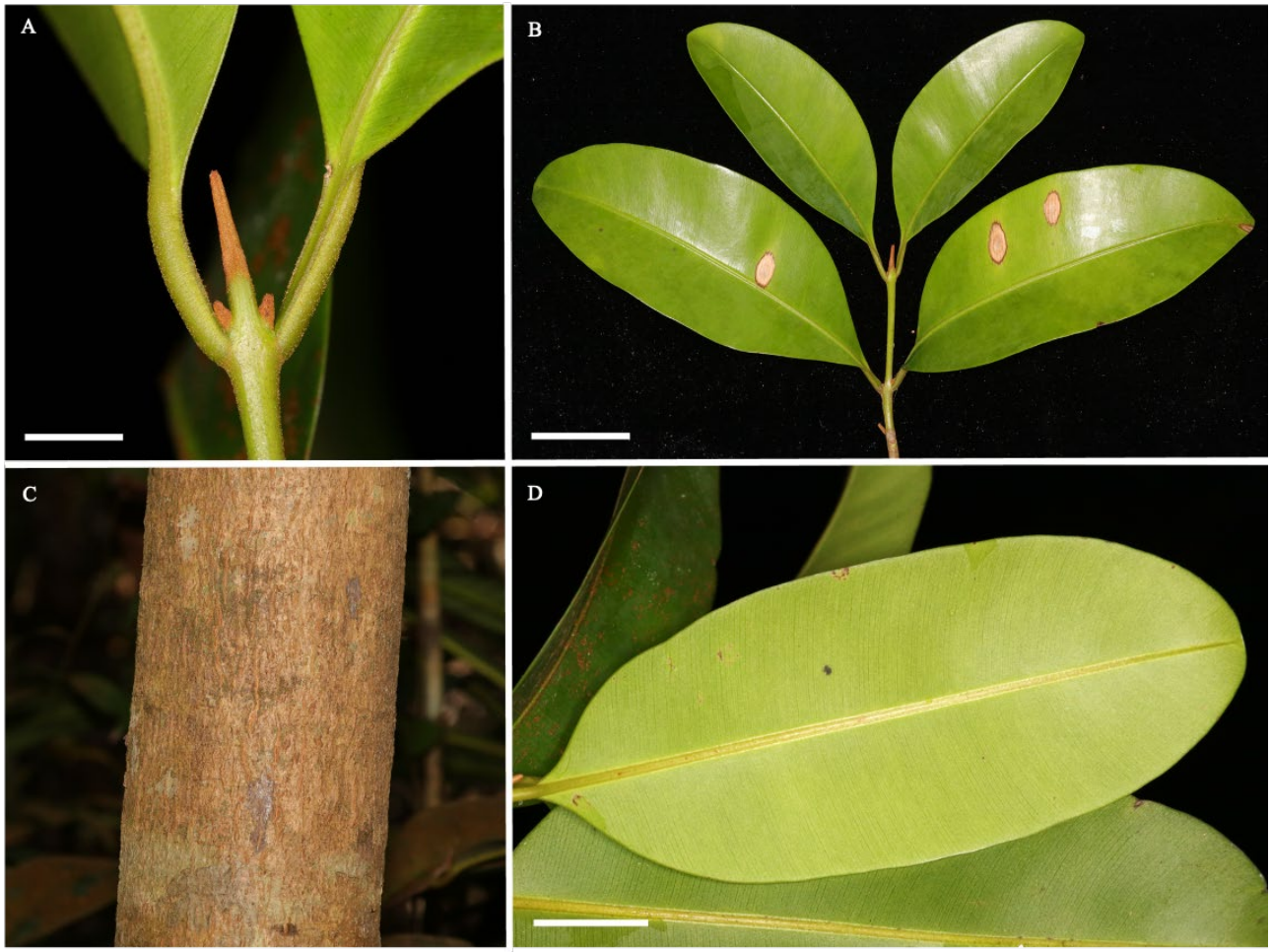

Fig. 15. *Calophyllum sundaicum*. A, Terminal bud covered with brown to greyish puberulent hairs; B, Leafy twig showing elliptic to oblong leaf blades; C, Brownish yellow bark with shallow and closely-spaced fissures; D, Leaf underside showing raised mid-rib and sub-obscure secondary veins. Scale bars = 0.5 cm [A]; 2 cm [B]; 1 cm [D].

9. *Calophyllum tetrapterum* Miq. **var. *tetrapterum***
(Greek *téttares*, four; *pteros*, winged; probably referring to the strongly four-angled young twigs)

Tree 6–30 m; trunk girth to 120 cm, without buttresses but sometimes with stilt roots. **Bark** whitish to yellowish or brown, closely fissured; inner bark reddish; latex clear to opaque yellow, rarely whitish, sticky. **Twigs** 1–3.5 mm across, slightly flattened, often strongly four-angled, drying yellowish to brownish, glabrous or sparsely brown-pubescent; uppermost axillary buds rounded, 0.5–1 mm; terminal buds plump, 1–4 mm long, covered with short grey/brown tomentose hairs. **Leaves** elliptic to obovate, 2.9–15.6 × 1.2–4.8 cm, sub-coriaceous; secondary veins conspicuous above and below, (5 to) 8 to 14 (to 17) veins per 5 mm; *midrib sharply raised above, raised/slightly raised and somewhat striate below*, glabrous or sparsely sub-tomentose/puberulent below; apex acute to acuminate; *margin noticeably paler*, *slightly thickened to 0.4 mm wide,* undulate but not recurved or slightly so; base cuneate to acute; petioles 3–15 mm long, deeply concave above, convex below, transiently puberulent below. **Inflorescence** axillary, 3–11 flowers, unbranched, lowest internode 4–35 mm long. **Flowers** bisexual, tepals 4 or 8 (rarely 5–7, or 10). **Fruit** spherical to ellipsoid, apex apiculate to rounded, greyish to pale brown when dry, 6.5–16 × 5–12 mm. — Fig. 16.

Singapore localities. NSSF (E. Tang & K. Sidek 776; A. Samsuri, S. K. Ganesan, P. Leong, A. T. Gwee & Mhd Noor NES 173), Upper Seletar Forest (A. T. Gwee SING 2011-332), Seletar Reservoir (J. Sinclair SFN 40014), Singapore Botanic Gardens, Pulau Pawai (S. Lee et al. SING 2006-51), Mandai Road (E. J. H. Corner SFN 33143), Mandai Forest (A. T. Gwee et al. SING 2009-24), Jurong (E. J. H. Corner s.n. SING barcode number 0044262), Bukit Timah Nature Reserve and secondary forests elsewhere within the CCNR (e.g., forests surrounding the MacRitchie and Upper Peirce reservoirs) and the Western Catchment.

Habitat. *Calophyllum tetrapterum* is commonly encountered in the NSSF and was recorded in both wet and dry plots. According to Stevens (1980: 510), it can be found in mixed dipterocarp forests, usually in well-drained areas. It is also commonly found growing in sandy, acidic soil, sometimes in highly leached podzols, swamp forests, evergreen forests, as well as on ultramafic rocks.

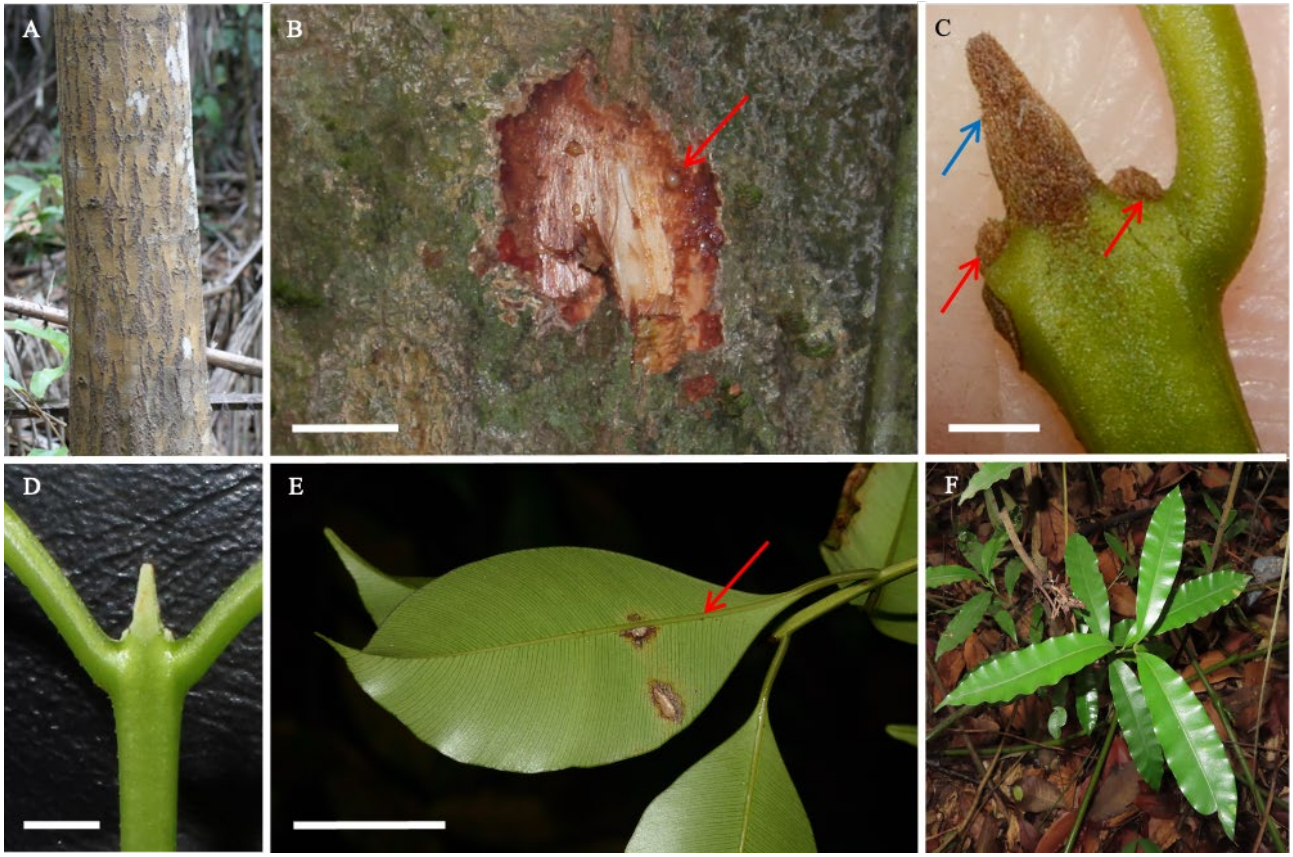

Fig. 16. *Calophyllum tetrapterum* var. *tetrapterum*. A, Greyish brown bark with widely-spaced fissures; B, Reddish inner bark and slightly opaque yellow latex (red arrow); C, Round uppermost axillary buds (red arrows) and conical terminal bud (blue arrow) covered with short greyish brown tomentose hairs; D, White terminal bud of a young shoot; E, Raised midrib below (red arrow); F, Young sapling with undulate, elliptic leaves. Scale bars = 2 cm [B, E]; 0.25 cm [C, D].

Conservation. Nationally Vulnerable (Tan et al., 2008).

Suggested common name. Four-angled bintangor.

Remarks. Some fresh specimens were observed to have white terminal buds (Fig. 16D). It appears that terminal buds of this species can occasionally be white and/or lighter-coloured when the shoots are young.

10. *Calophyllum teysmannii* Miq. var. *teysmannii*

(After Johannes Elias Teijsmann, anglicised to Teysmann, 1801–1882, a Dutch botanist and plant collector)

Tree 3–36 meters tall; trunk girth to 298 cm. **Bark** greyish brown, fissured and scaly; inner bark red; latex clear yellow to opaque. **Twigs** 1–3 mm across, slightly to distinctly flattened, horizontal lines at nodes, drying brown to blackish, transiently puberulent to sub-persistently tomentose; uppermost axillary buds rounded, 2–5 mm long; terminal buds conical to plump, 3–9 mm long, covered with sericeous to tomentose hairs, *usually enclosed by the upright petioles of the uppermost pair of leaves*. **Leaves** usually obovate, rarely sub-oblong, sub-obovate, sub-orbicular, or cuneiform, 3.0–13.2 × 1.4–5.4 cm, coriaceous to very coriaceous; secondary veins sub-obscure to obvious above and below, (4 to) 6 to 12 (to 21) veins per 5 mm; midrib flat to raised above, strongly raised, striate and angled below, transiently puberulent on midrib on both surfaces; apex retuse, rounded, or acute; *margin thickened, 0.4–1.2 mm wide*, undulate and sharply recurved; base acute to cuneate, rarely rounded; petioles 4–14 mm long, broadly and shallowly concave above, convex below, sometimes sub-persistently tomentose, drying brownish to blackish. **Inflorescence** borne from leaf axils near the apex and along twigs, 3–11 flowers, unbranched, rarely with three-flowered branches up to 12 mm long and/or flabellate, lowest internode (7–)15–34 mm long. **Flowers** bisexual, tepals 4–8. **Fruit** ellipsoid to spherical, apex rounded, maroon to dark red and more or less smooth when dry, 17–37 × 14–32 mm. — Fig. 17.

Singapore localities. NSSF (A. Samsuri, S. Lee, A. T. Gwee, P. Leong & Mhd Noor NES 391), Upper Peirce Reservoir, Upper Seletar Reservoir (A. T. Gwee SING 2010-618)/ Upper Seletar Forest (A. T. Gwee SING 2011-323)/ Seletar Reservoir, Mandai Forest/Road, MacRitchie Reservoir and Bukit Timah Nature Reserve (C. F. Baker s.n. SING barcode number 0017936).

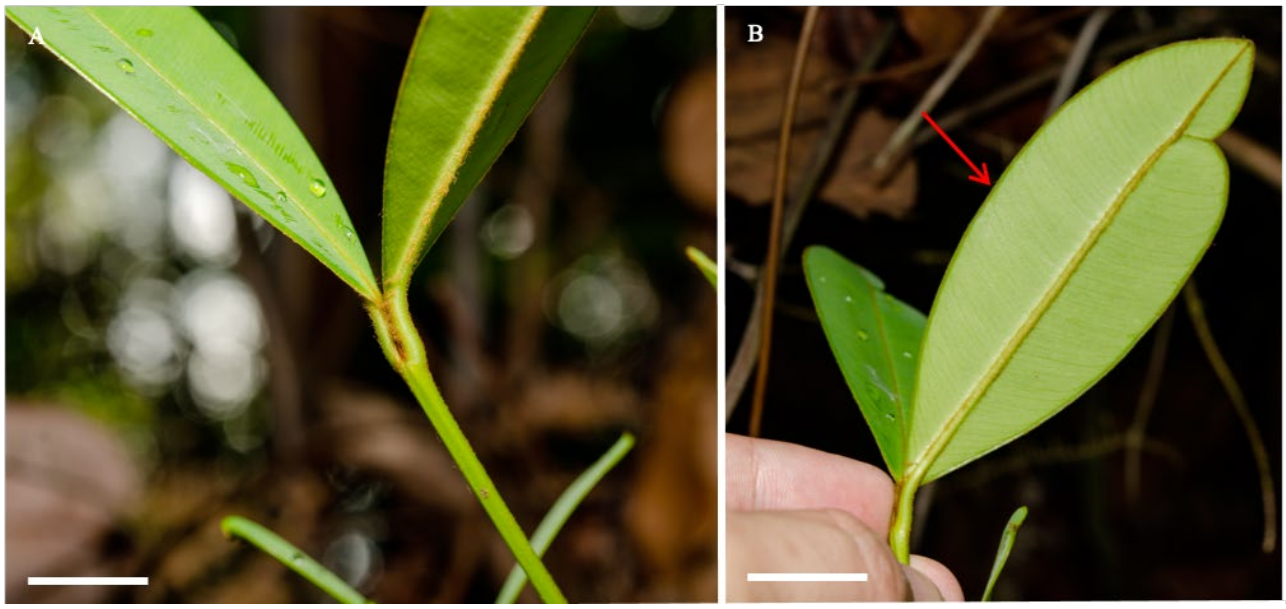

Fig. 17. *Calophyllum teysmannii* var. *teysmannii*. A, Terminal bud covered with tomentose hairs and enclosed by the upright petioles of the uppermost pair of leaves; B, Leaf underside showing sharply recurved, thickened margin (red arrow) and strongly raised, transiently tomentose midrib below. Scale bars = 2 cm [A, B].

Fig. 18. Galls growing on the twigs of a *Calophyllum teysmannii* var. *teysmannii* specimen. Scale bar = 1 cm.

Habitat. In the NSSF, it was found in both wet and dry plots. Outside of the NSSF in Singapore, this species has been found to be relatively widespread in the mature dry-land secondary forests. According to Stevens (1980: 435), it can be found in mixed dipterocarp forests, peat swamps, kerangas and ridges in lower montane rainforests, up to 1220 m in altitude.

Conservation. Nationally Vulnerable (Tan et al., 2008).

Suggested common name. Teysmann's bintangor.

Remarks. Galls have been observed growing on the twigs of some *Calophyllum teysmannii* specimens (Fig. 18). These structures could be mistaken as fruits. Anthony (1974) recorded various types of galls on specimens of some *Calophyllum* species in Singapore (e.g., moth-galls and midge-galls on *Calophyllum ferrugineum*, moth-galls, psyllid-galls and midge-galls on *Calophyllum pulcherrimum* and psyllid-galls and coccid-galls on *Calophyllum teysmannii*). Both Anthony (1974) and Stevens (1980) reported bilabiate galls on *Calophyllum teysmannii*; this observation was made by us too. Additionally, Stevens (1980) states in his account that "slitlike galls also frequently appear on *Calophyllum teysmannii*".

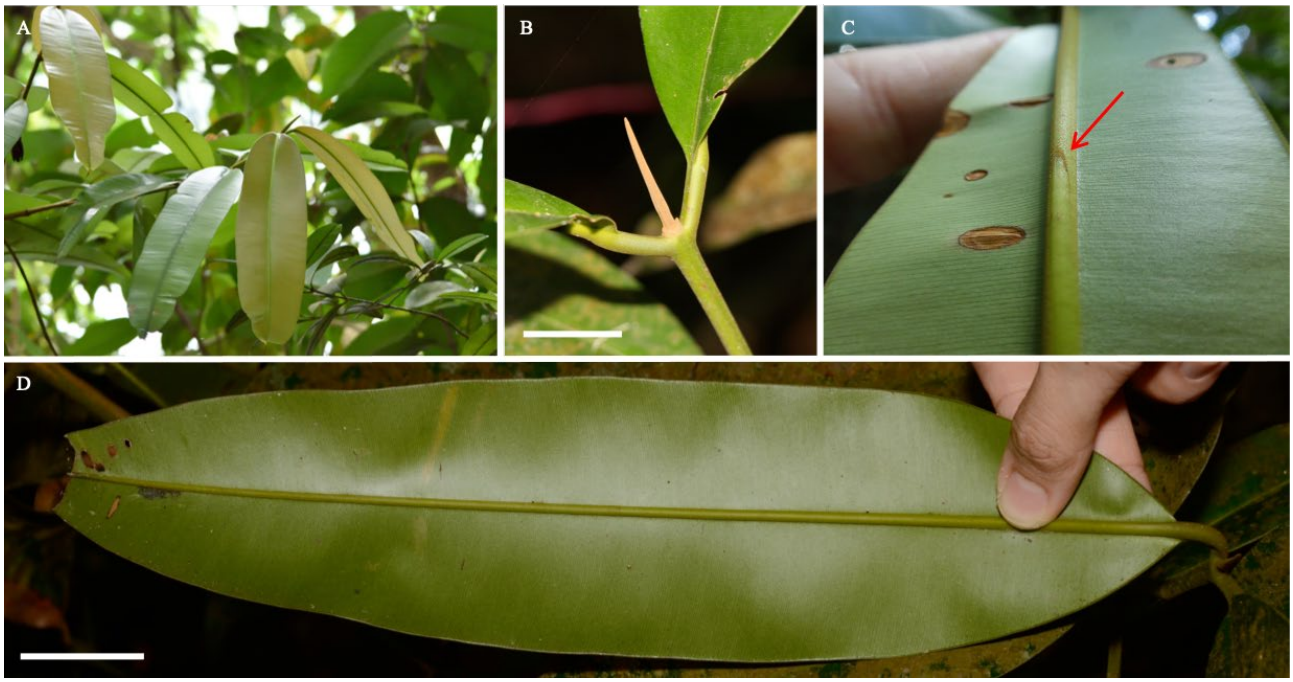

Fig. 19. *Calophyllum wallichianum* var. *incrassatum*. A, Leafy twig with light pinkish young leaves; B, Long conical terminal bud covered with brown sub-tomentose hairs and obscurely four-angled young twig; C, Midrib below covered with brown puberulent hairs that can be rubbed off easily (red arrow); D, Oblong leaf blade and midrib strongly raised below. Scale bars = 2 cm [B, D].

11. *Calophyllum wallichianum* Planchon & Triana **var. *incrassatum*** (Henderson & Wyatt-Smith) P.F.Stevens
(After Nathaniel Wolff Wallich, 1786–1854, a Danish botanist;
Latin *incrassatus*, thickened; referring to the pedicel that thickens in the fruit)

Tree (3–)15–36 meters tall; trunk girth to 502 cm, usually without buttresses. **Bark** yellowish grey to brown, shallowly fissured or with distant vertical lenticels, coarsely fissured in large trees; inner bark red; latex usually white, often turning yellowish, fairly sticky. **Twigs** 2–5 mm across, slightly flattened, obscurely to strongly four-angled, drying yellowish brown to blackish, inconspicuously grey to brown puberulent, rarely sub-tomentose, when young; uppermost axillary buds pointed to rounded, 1–4 mm long; terminal buds conical/long and narrow to plump, 16–30 mm long, covered with grey to brown crustaceous to sub-tomentose hairs, *striate*. **Leaves** *large, oblong to sub-ovate*, rarely ovate, (4.0–)15.0–34.0 × (0.9–)3.2–9.0 cm, coriaceous, rarely thickly coriaceous; secondary veins sub-obscure to apparent above and below, (8 to) 10 to 17 veins per 5 mm; midrib above often depressed at first, becoming raised subsequently and usually prominent, midrib above rarely/almost never surrounded by raised lamina, *strongly raised to striate/angled below*, sub-persistently farinose-puberulent on midrib below and often above; apex acute to sub-acuminate; margin notably undulate and not recurved to moderately so; base acute to cuneate or rounded; petioles (4–)11–25(–50) mm long, broadly concave above, convex below, *glabrous or with obscure hairs*, often drying blackish. **Inflorescence** borne from leaf axils, 7–19 flowers, unbranched (rarely with five-flowered branches up to 15 mm long), lowest internode 4–11 mm long. **Flowers** bisexual; tepals 4 (rarely 6). **Fruit** ellipsoid to ovoid or spherical, apex strongly apiculate or otherwise, brown to blackish and shallowly and sharply wrinkled when dry, 20–30(–35) × 15–25(–30) mm. — Fig. 19.

Singapore localities. NSSF (A. Samsuri, S. Lee, A. T. Gwee, Mhd Noor, P. Leong & S. K. Ganesan, NES 17), Upper Seletar Reservoir (A. T. Gwee, P. T. Chew, H. K. Lua & D. Liew et al. SING 2008-117)/ Seletar Firing Range (A. T. Gwee & P.T. Chew SING 2009-108), Sungei "Muara" (H. N. Ridley 5071), Mandai, Chestnut Track (A. T. Gwee SING 2008-318)/ Chestnut Area (A. T. Gwee SING 2010-559), Bukit Timah Nature Reserve and secondary forests elsewhere within the CCNR (e.g., the Mandai forests and those surrounding the Upper Peirce Reservoir).

Habitat. In the NSSF, it was found predominantly in wet plots but also sometimes in dry plots. Outside of the NSSF in Singapore, this species has been found to be widespread in mature dry-land secondary forests. According to Stevens (1980: 345), it can be found in mixed dipterocarp lowland forests, in well-drained areas and it also grows in swamp forests and mossy heath forests, 6–1,220 m in altitude.

Conservation. Nationally Vulnerable (Tan et al., 2008).

Suggested common name. Wallich's bintangor.

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